

# **Water Quality Standards Workgroup Meeting**

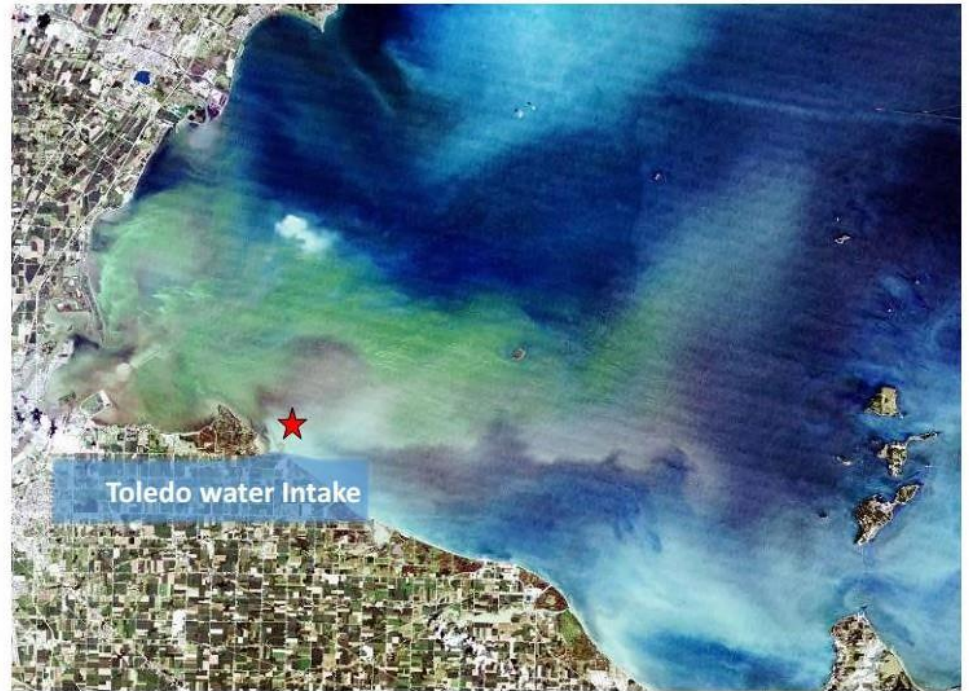
**Lake Numeric Nutrient Criteria  
November 10, 2015**

# Drinking Water Supply Beneficial Use - 10 CSR 20-7.031(C)6

- **Drinking Water Supply** – *Maintenance of a raw water supply which will yield potable water after treatment by public water treatment facilities.*



# EPA Health Advisories for Cyanotoxins



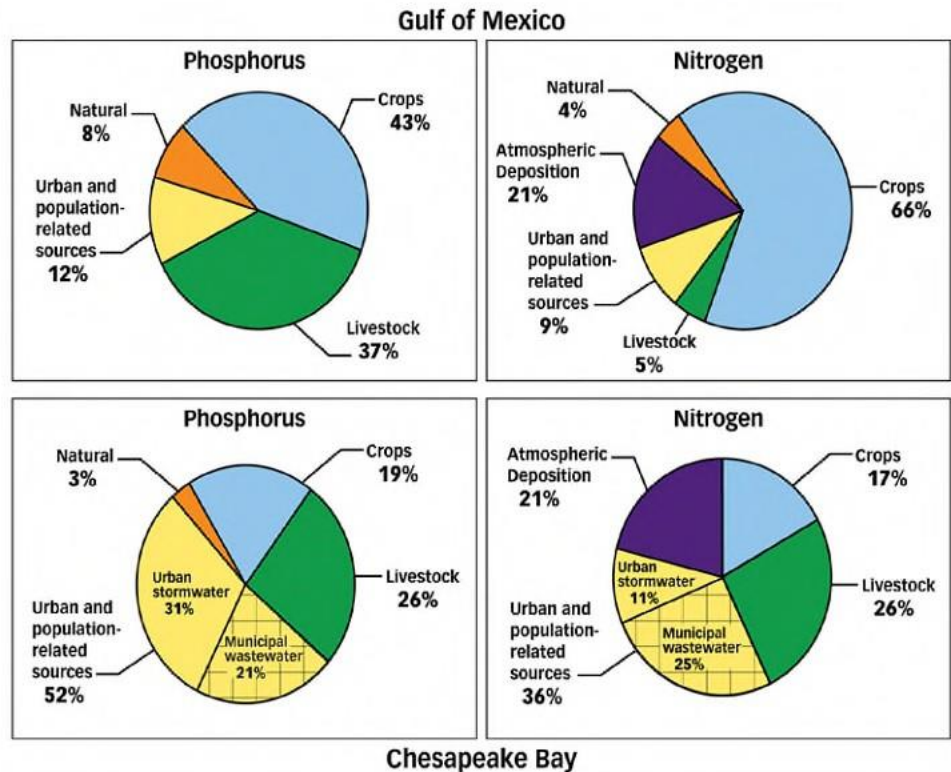
Lesley D'Anglada  
Health and Ecological Criteria Division  
Office of Science and Technology  
Office of Water

May 11, 2015  
Stakeholder Meeting

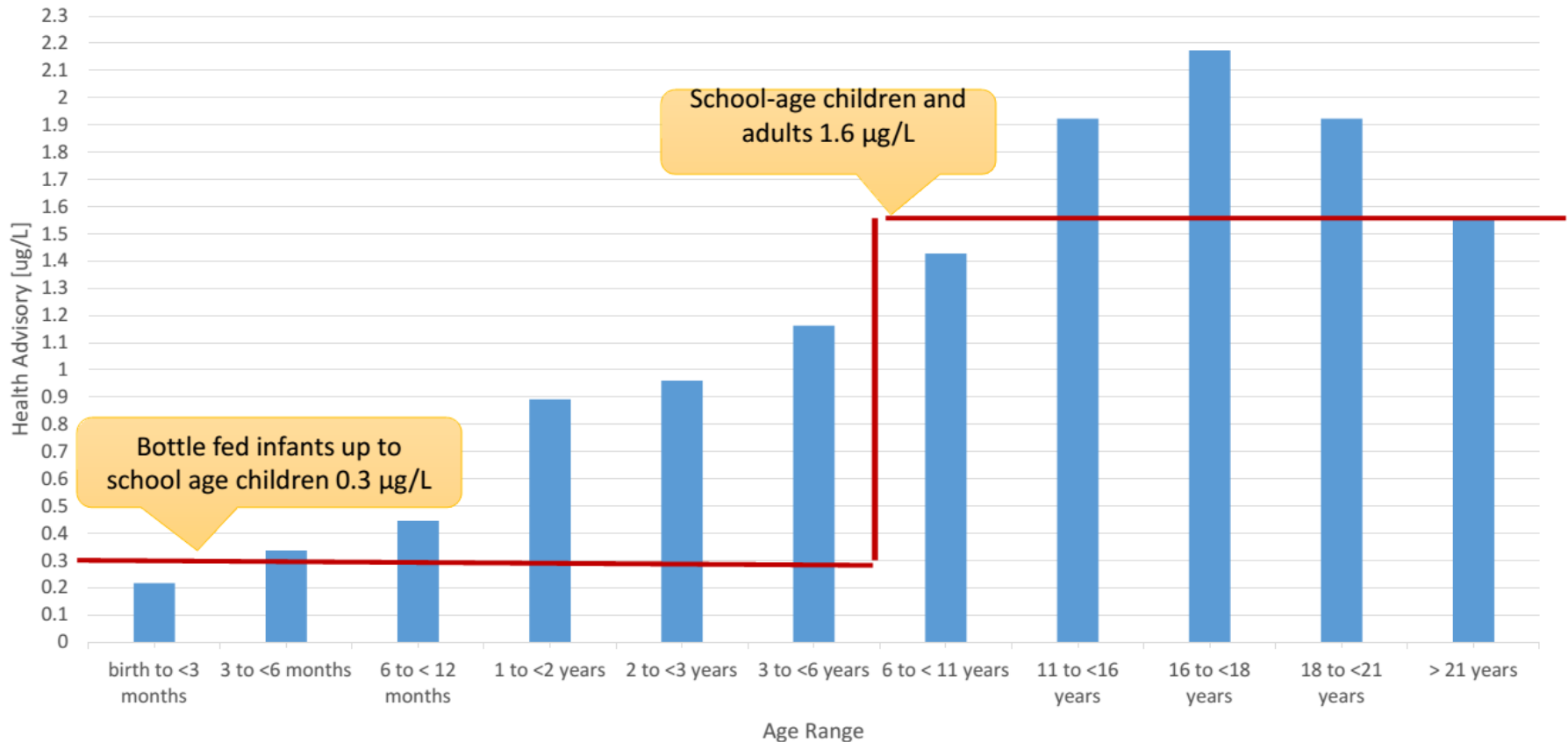
# Causes of Nutrient Pollution

- Nitrogen and phosphorus support the growth of algae and aquatic plants, which provide food and habitat for fish, shellfish and smaller organisms that live in water
- But when too much nitrogen and phosphorus enter the environment – usually from human activities – algae, including HABs, can grow excessively
- Very recent work has suggested that high concentrations of nitrogen are linked to increased concentrations of microcystins

## Relative Nutrient Source Contributions



# EPA Microcystins Health Advisory by Age Group



# Ohio State Drinking Water Guidance/Action Level

Do Not Drink – children under 6 and sensitive populations (pregnant women, elderly and immune-compromised individuals)

Microcystin: 0.3 µg/L

Anatoxin-a: 20 µg/L

Cylindrospermopsin: 0.7 µg/L

Saxitoxin: 0.2 µg/L

Do Not Drink – children 6 and older and adults

Microcystin: 1.6 µg/L

Anatoxin-a: 20 µg/L

Cylindrospermopsin: 3.0 µg/L

Saxitoxin: 0.2 µg/L

Do Not Use (based on the Recreational No Contact Advisory thresholds)

Microcystin: 20 µg/L

Anatoxin-a: 300 µg/L

Cylindrospermopsin: 20 µg/L

Saxitoxin: 3 µg/L



# **Potential Actions Public Water Systems and States Can Take to Prepare for and Respond to Cyanotoxin Health Risks in Drinking Water**

Presenter: Ryan Albert  
Office of Ground Water and Drinking Water

May 11, 2015  
Stakeholder Meeting



## Setting the Stage: Definitions

*(For purpose of this presentation)*

- Source water – water from lakes, reservoirs, rivers, or streams that is used as a drinking water source
- Raw water – water that enters the drinking water intake, but has not yet received any treatment
- Finished water – “water that is introduced into the distribution system of a public water system and is intended for distribution and consumption without further treatment, except as treatment necessary to maintain water quality in the distribution system. . . .”  
(40 CFR 141.2)



# Setting the Stage: Microcystin Methods Overview

Summary Options	ELISA-Field (Tube/Strips)	ELISA-Lab	HPLC-UV (PDA)	HPLC-MS/MS
Specificity	Total Microcystins	Total Microcystins	Total Microcystins— limited specificity	6 Specific Microcystin congeners (EPA method 544)
Approx. Limit of Quantification (LOQ)	~0.5 – 1 ug/L	~ 0.3 µg/L	~ 0.3 µg/L	~ 0.02 µg/L
Time to result	10 – 60 minutes	4 hours or less	~ 1 day	~ 1 day
Estimated Cost per Analysis	\$30-100	\$50-150	\$150-250	\$200-350



# Setting the Stage: Treatment Overview

- Conventional treatment is effective in removing cyanobacterial cells (containing intracellular cyanotoxins)
  - Greater than **90%** cell removal when using coagulation, sedimentation, and filtration
  - Greater than **80%** buoyant cell removal when using coagulation/flocculation and Dissolved Air Flotation (DAF)
  - Adjustment of current treatment may achieve higher levels of cell removal
  - Conventional treatment is not consistently effective for removal of dissolved (extracellular) cyanotoxins
  - Pre-oxidation can lyse the cells, releasing toxins and increasing the problem (by increasing dissolved cyanotoxins)



## Setting the Stage: Treatment Overview

- Activated Carbon is effective in removing cyanotoxins
  - Powdered Activated Carbon (PAC) has greater than 80% removal efficacy for dissolved cyanotoxins
  - Ineffective for removal of cells containing intracellular toxins
  - Jar testing can be used to determine an effective PAC dose
- Ozone is effective in oxidizing dissolved cyanotoxins
  - Ozone documented to destroy greater than 95% of dissolved cyanotoxins
  - Given adequate dosing, ozone can achieve destruction of cells as well as the dissolved toxins released due to cell lysis caused by ozone
  - May increase the potential for the formation of bromate and other disinfection byproducts



## Step 1: Conduct System Specific Evaluation

Source water vulnerable

Source water not vulnerable

## Step 2: Preparation and Observation

YES, evidence indicates cyanotoxin occurrence

NO, continue to assess evidence during vulnerable period

## Step 3: Monitor for Cyanotoxins in Raw Water and Treatment Adjustments

YES, toxins detected

NO toxin detected

## Step 4: Monitor for Toxins in Raw and Finished Water and Treatment Adjustments

Toxins detected in raw only, continue raw and finished water monitoring

Toxins detected in finished water

NO toxins detected in raw or finished water

Continue monitoring if bloom is visible. If bloom no longer visible continue to evaluate evidence for cyanotoxin occurrence

## Step 5: Monitor for Toxins in Finished Water, Treatment Adjustments/Additions, and Public Communications

# Preliminary Approach to Determine Whether Cyanotoxins are Present in Drinking Water

## Step 5: Monitor for Toxins in Finished Water, Treatment Adjustments, and Public Communications

### Low Level

Microcystins:  $\leq 0.3 \mu\text{g/L}$



### Medium Level

Microcystins:  $> 0.3 \mu\text{g/L} \leq 1.6 \mu\text{g/L}$



### High Level

Microcystins:  $> 1.6 \mu\text{g/L}$



#### ***Communication***

Continue communication with State primacy agency and local health officials on monitoring results.

Notify local public health agency, primacy agency and the public. Recommend use of alternative sources for children younger than school-age.

Notify local public health agency, primacy agency and the public. Recommend 'Do Not Drink/ Do Not Boil Water' advisory for all consumers.

#### ***Treatment Actions***

Modify treatment as necessary to keep algal toxins below HA values.

Adjust existing treatment to reduce the concentration to below  $0.3 \mu\text{g/L}$  (MC) as soon as possible. Modify or amend treatment as necessary.

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#### ***Monitoring***

Continue sampling raw and finished water at least 2-3 times per week until levels are below quantification in at least 2-3 consecutive samples in raw water, then return to Step 3.

Continue sampling raw and finished water daily until finished water levels are below quantification in at least 2-3 consecutive samples.

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# A Water Utility Manager's Guide to Cyanotoxins



American Water Works  
Association

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Water  
Research  
Foundation™

advancing the science of water

# Eutrophication Impacts to Drinking Water Utilities

- **Increased organic compounds that serve as precursors for disinfection byproducts**
  - Trihalomethanes
  - Haloacetic acids
- **Taste and odor compounds**
  - Trans-1,10 dimethyl-trans-9-decalol (geosmin)
  - 2-methylisoborneol (MIB)
- **Cyanobacterial toxins**
  - Microcystins
  - Cylindrospermopsin
  - Anatoxin-a
  - Saxitoxin

# Proposed Drinking Water Supply Criteria and Screening Values

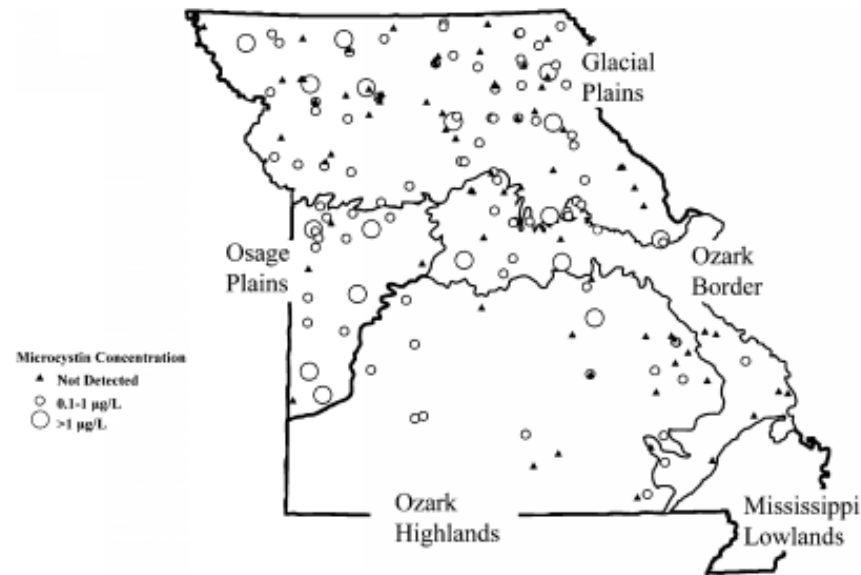
**Table L: Lake Ecoregion Nutrient Criteria and Long-Term and Short-Term Screening Values (µg/L)**

Lake Ecoregion	Chl-a Criterion	Short-Term Screening Value			Long-Term Screening Value		
		TP	TN	Chl-a	TP	TN	Chl-a
Plains (DWS)	26	65	1,000	26	26	560	10
Plains (AQL)	40	100	1,300	40	50	850	20
Ozark Border (DWS)	26	70	1,000	26	29	600	10
Ozark Border (AQL)	22	60	960	22	26	580	9.0
Ozark Highland (DWS)	26	52	1,000	26	24	550	10
Ozark Highland (AQL)	15	34	700	15	18	430	7.0

# Eutrophication Impacts to Drinking Water Utilities

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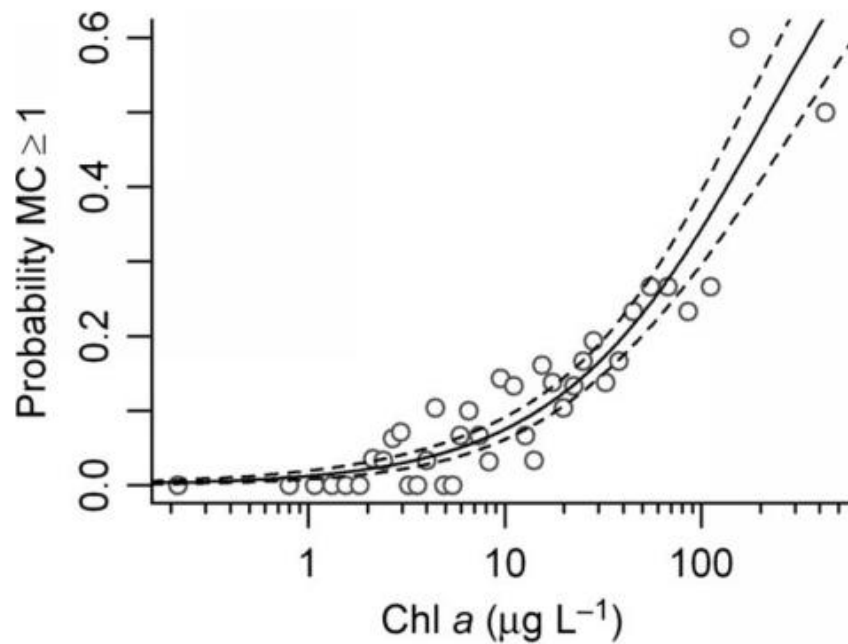
# Microcystin in Missouri Reservoirs (Graham and Jones, 2009)



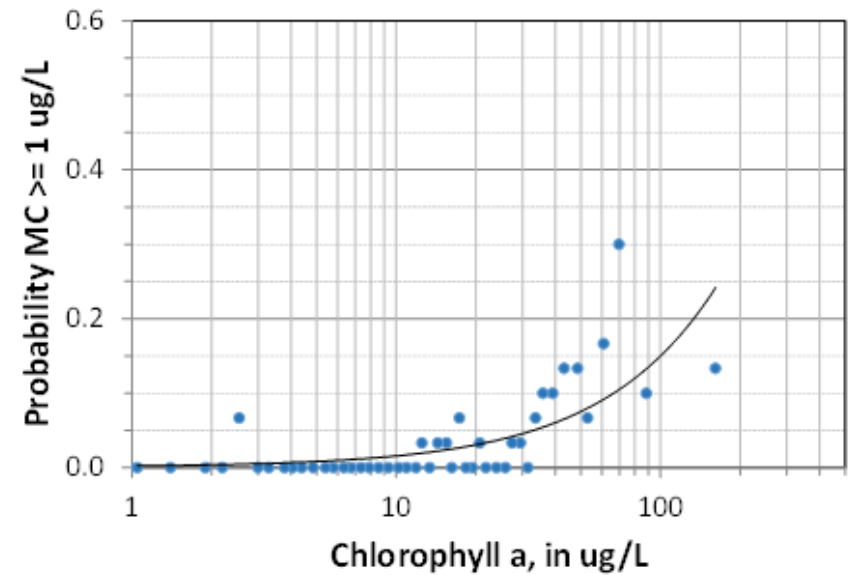
Total Microcystin (ug/L)	n	Chl-a Median (ug/L)	Chl-a Range (ug/L)
nd	1,082	11	1-252
0.1-1	271	26	1-267
>1	49	49	2-131

# Microcystin National vs Missouri Dataset

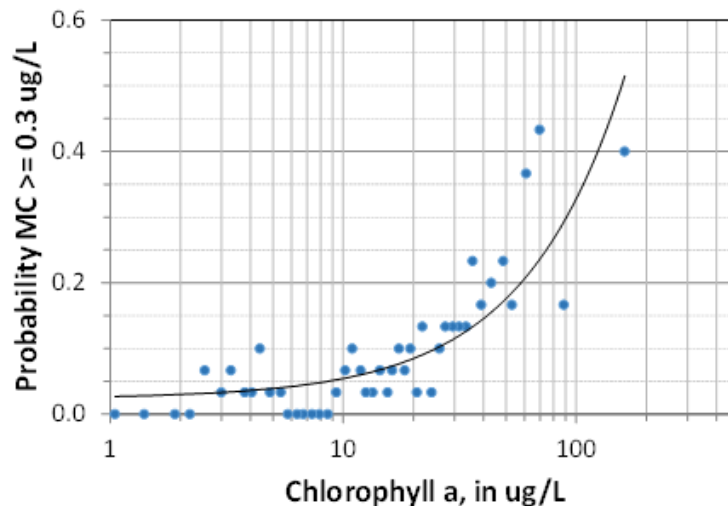
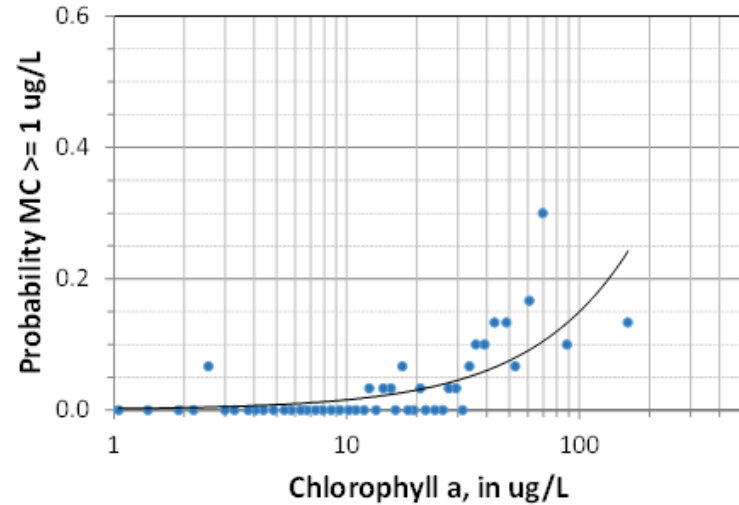
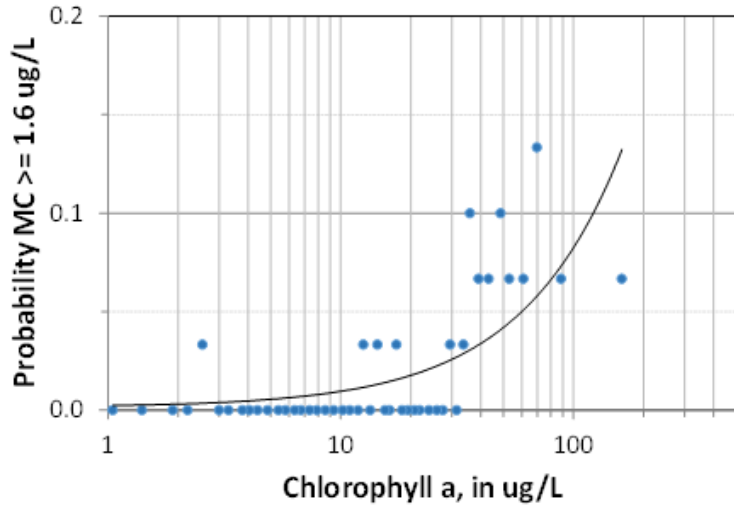
National Dataset (Yuan, 2014)



Missouri Dataset  
(Graham and Jones, 2009)



# Microcystin (Missouri Dataset) – Probability Comparison of Different MC Levels



## Reservoirs with at least 4 Microcystin samples $\geq 0.3$ ug/L

Reservoir	Region	# samples $\geq 0.3$ ug/L	Median MC (ug/L)	Long-term Chl Geomean (ug/L)	Range of Annual Chl Geomeans (ug/L)	Chl Geomean Period
Bilby Ranch	Plains	20 of 26	0.89	25	12-38	2003, 2005-2012
Bushwacker	Plains	6 of 8	0.67	12	8-23	2003, 2005, 2009
Harrison Co.	Plains	7 of 26	0.86	37	21-39	2008-2012
Kraut Run	Plains	4 of 7	1.69	69	50-102	2003-2012
LaBelle #2	Plains	6 of 12	6.25	42	39-58	2003-2007, 2010-2011
Little Dixie	Plains	5 of 12	0.47	31	18-49	2003-2013
Marceline City	Plains	11 of 22	11.24	30	18-60	2005-2010
McCredie	Plains	4 of 4	1.18	72	na	na
Ben Branch	Ozark High.	4 of 4	1.48	12	5-19	2007-2009, 2011-2012
Indian Hills	Ozark High.	4 of 4	0.78	24	24	2003-2004

# Drinking Water Compliance Report

## Disinfection Byproducts - MCL Violations (2010-2014)

System	Waterbody	Total Trihalomethane	Total Haloacetic Acids
Adrian	Adrian Lake, South Grand River	2014	--
Bowling Green	Lake #1, Lake #2	2011	--
Breckenridge	Breckenridge Lake	2010-2012	2010
Bucklin	Mussel Fork Creek, Bucklin Lake	2011-2012	2010
Daviess Co PWSD 3	Lake Viking	2010-2011	--
Fredericktown	Fredericktown Lake	--	2014
Garden City	Garden City Lake, New Lake	2010-2013	--
Hamilton	Marrowbone Creek, Hamilton Lake	2010-2012	--
Lamar	Lamar Lake	2010	--
Maysville	Willowbrook Lake	2010-2011, 2013-2014	--
Memphis	Memphis New Lake, Memphis Old Lake	2013	2013

Note: This table does not represent an exhaustive list of all DBP MCL violations. This table excludes system violations where the waterbody could not be identified or was not a reservoir, or where water quality data could not be located. Additionally, where a system pulls water from multiple sources, it is unclear which source caused the MCL violation.

# Disinfection Byproduct Data Summary

Drinking Water Reservoir	Region	Long-term Chl Geomean (ug/L)	Range of Annual Chl Geomeans (ug/L)	Period
Adrian Lake	Plains	33	29-37	2011-2012
Bowling Green Lake Old	Plains	6	0.3-27	2003-2010, 2013
Breckenridge Lake	Plains	13	5-62	2003, 2010-2011
Bucklin Lake	Plains	23	9-55	2010-2012
Garden City #1	Plains	38	38	2011
Garden City #2	Plains	49	49	2012
Lamar Lake	Plains	47	31-76	2003-2010, 2013
Memphis Lake #1	Plains	44	44	2009
Memphis Lake #2	Plains	35	34-35	2005-2006
Vandalia Reservoir	Plains	21	16-29	2011-2012
Lake Viking	Plains	7	5-14	2003, 2005-2012
Willowbrook Lake	Plains	28	24-36	2005-2006
Fredericktown Lake	Ozark High.	31	28-34	2004-2005, 2008

# Summary of Microcystin and Disinfection Byproduct Data

## ▪ Microcystin Summary

- Mean = 35 ug/L
- Median = 31 ug/L
- Range = 12-72 ug/L

## ▪ Disinfection Byproduct Summary

- Mean = 29 ug/L
- Median = 31 ug/L
- Range = 6-49 ug/L

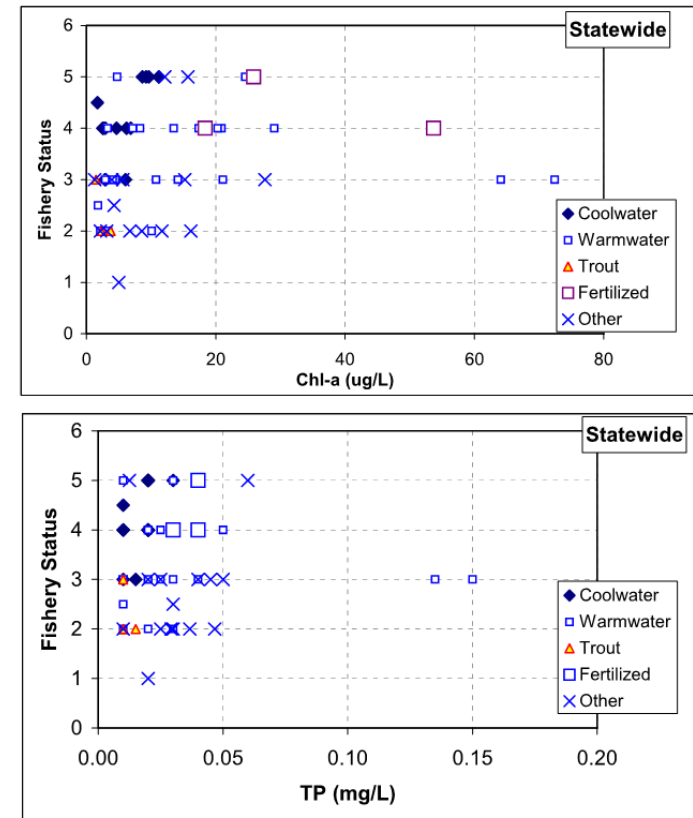
# Aquatic Life Protection - 10 CSR 20-7.031(C)1.A.,B.,C.

- **Warm Water Habitat** – *Waters in which naturally-occurring water quality and habitat conditions allow the maintenance of a wide variety of warm-water biota.*
- **Cool Water Habitat** - *Waters in which naturally-occurring water quality and habitat conditions allow the maintenance of a wide variety of cool-water biota. These waters can support a sensitive, high-quality sport fishery (i.e., smallmouth bass and rock bass).*
- **Cold Water Habitat** - *Waters in which naturally-occurring water quality and habitat conditions allow the maintenance of a wide variety of cold-water biota. These waters can support a naturally reproducing or stocked trout fishery and population of other cold-water species.*



# Virginia's Method for Developing Nutrient Criteria for Reservoirs

- Nutrient criteria recommendations developed by Academic Advisory Committee
- **Premise** – Status of the recreational fishery can be considered as an indicator of the impoundments' suitability for aquatic life
- **Method**
  - Literature review
  - The status of the recreational fishery in each impoundment was rated on a scale of 1 (poor) to 5 (excellent) by VDGIF biologists
  - Data analysis was conducted by plotting fishery status against Chl-a and TP
  - The plots did “**not yield well-defined relationships**. We believe the reason for this is size variability. . . . Generally, fish populations in small lakes are more subject to influence by non-nutrient factors . . . Non-nutrient factors . . . include inorganic turbidity (suspended sediments) and lake physical features and structural elements.”



# Proposed Aquatic Life Criteria and Screening Values

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# MU/MDC Sport Fish Study



## Fish Species:

**Largemouth Bass, Bluegill, Redear Sunfish, White Crappie and Black Crappie**

## Measures of Fishery Health:

**Catch per Effort (CPE) How many fish are there?**

**Proportional Size Distribution (PSD) Are they all small fish fish?**

**PSD of Preferred-size Fish (PSD-P) Are there lots of big/trophy fish?**

**Mean Length at Age 3 (ML3) How fast do the fish grow?**



# **MU/MDC Sport Fish Study**

## **Environmental Data:**

**TP**

**CHL**

**Lake Surface Area**

**Watershed Area : Lake Area Ratio**

**Non-Volatile Suspended Solids (measure of turbidity)**

**Urban Land Cover**

**Aquatic Vegetation (sparse or abundant)**

**Gizzard Shad (present or not)**

**Common Carp (present or not)**

**Various population measures of the five game fish species**

# MU/MDC Sport Fish Study



	CPE	PSD	PSD-P	ML3
Largemouth Bass				
Bluegill				
Redear Sunfish				
White Crappie				
Black Crappie				

# MU/MDC Fish Sport Study



	CPE	PSD	PSD-P	ML3
Largemouth Bass	BLGCPE	TP	LMB <sub>CPE</sub>	SA
Bluegill	LMB <sub>CPE</sub>	LMB <sub>CPE</sub>	LMB <sub>CPE</sub>	LMB <sub>PSD-P</sub>
Redear Sunfish	LMB <sub>PSD</sub>	RED <sub>CPE</sub>	RED <sub>CPE</sub>	TP
White Crappie	NVSS	BLGCPE	LMB <sub>CPE</sub>	WHC <sub>CPE</sub>
Black Crappie	LMB <sub>PSD</sub>	BLGCPE	CHL	LMB <sub>PSD-P</sub>



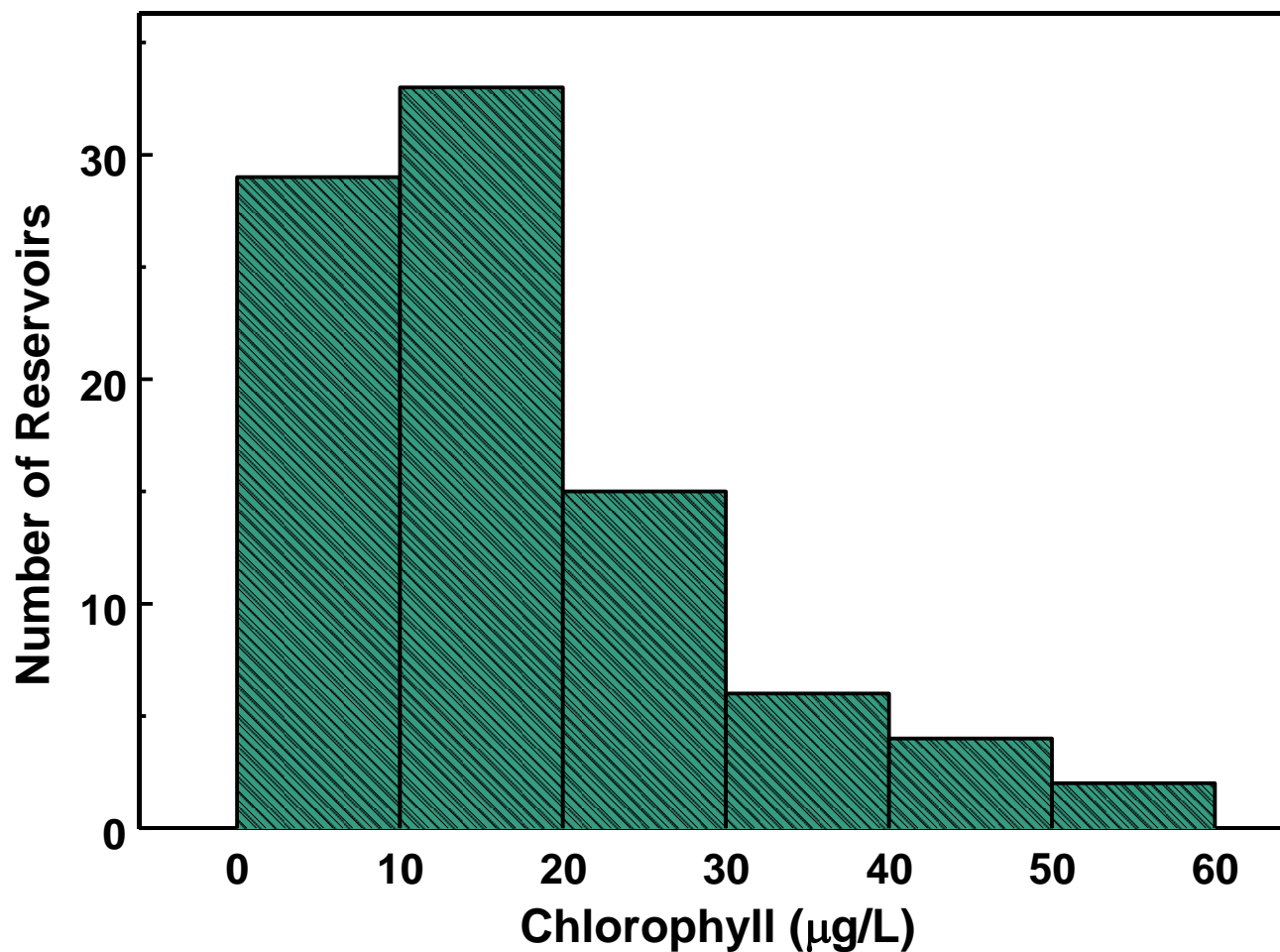
# MU/MDC Sport Fish Study

- **Objective** - Examine the relative importance of watershed characteristics, impoundment morphology, water quality, and species interactions in explaining difference in relative abundance, growth, and size structure of largemouth bass, bluegill, redear sunfish, white crappie and black crappie among small Missouri impoundments.
- **Findings**
  - Numerous influences affect sport fish populations.
  - Variable associated with predation, competition, and lake fertility were most important in explaining variation in sport fish demographics.
  - Largemouth bass predation was a strong force in structuring sunfish and crappie populations.
  - Bluegills are positively associated with largemouth bass
  - TP and Chl were positively associated with growth and size structure of largemouth bass, bluegill, redear sunfish, and black crappies.
  - For black crappie PSD-P and largemouth bass PSD there seemed to be a threshold at Chl of 40-60 ug/L, beyond which these size structure variables declined.
  - Largemouth bass and redear sunfish CPE declined with increased lake fertility but were especially low for most lakes with TP>100 ug/L or Chl > 40-60 ug/L.

# MU/MDC Sport Fish Study



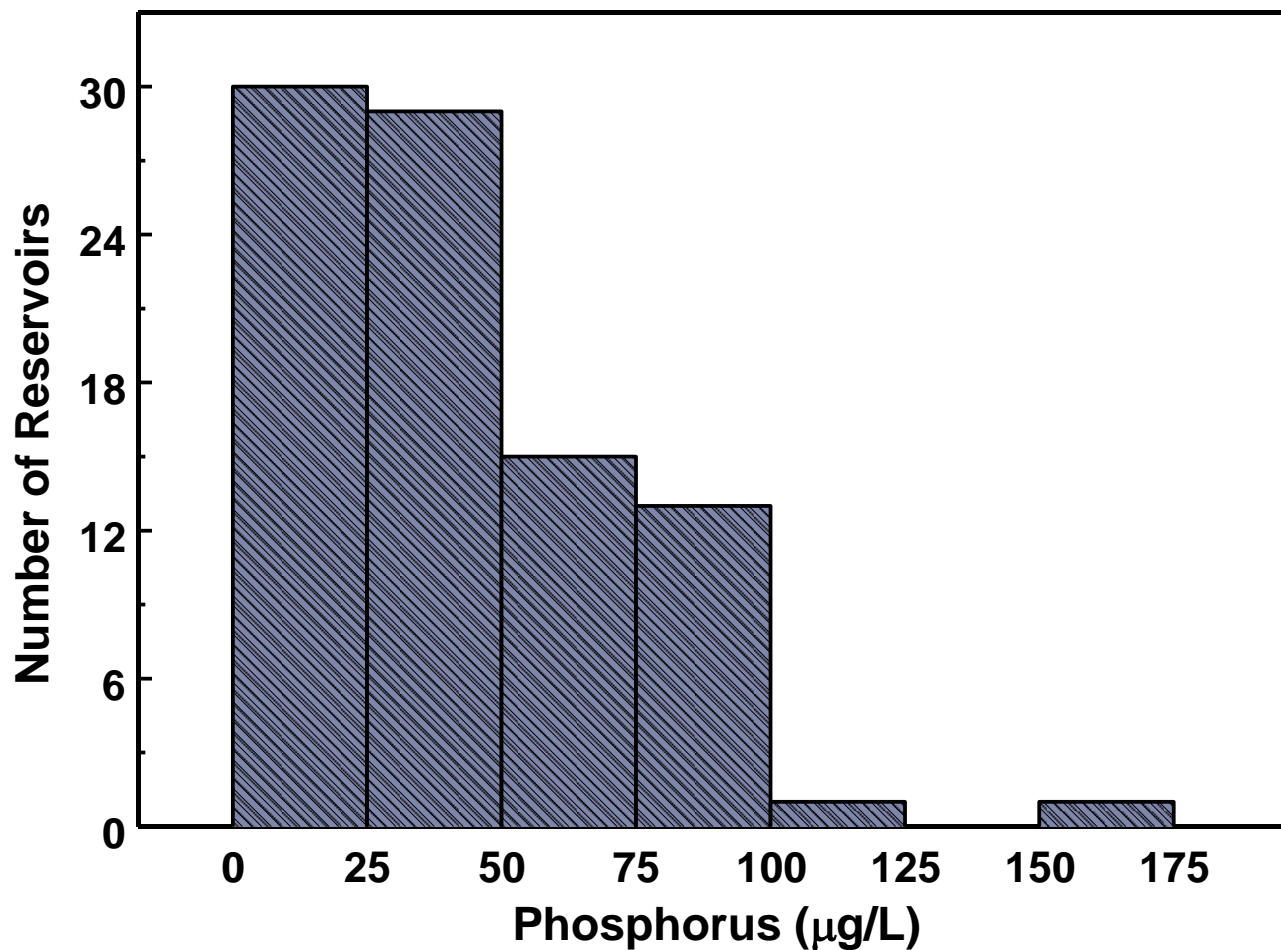
Data Distribution for Small MO Impoundment Study



# MU/MDC Sport Fish Study



Data Distribution for Small MO Impoundment Study



# MU/MDC Recommendations



Physiographic section	Primary fish species		Water quality conditions <sup>a</sup> Mean (range)	Proposed criteria <sup>b</sup>
	Small impoundments (<1,000 acres)	Large reservoirs (≥1,000 acres)		
Glacial Plains	Largemouth bass, bluegill, white crappie, black crappie, redear sunfish, green sunfish, gizzard shad, common carp (invasive), channel catfish (stocked)	Largemouth bass, bluegill, white crappie, black crappie, gizzard shad, common carp (invasive), channel catfish, flathead catfish, blue catfish, freshwater drum, white bass, bigmouth buffalo, smallmouth buffalo, river carpsucker, longnose gar, shortnose gar	Chla: 21.6 µg/L (2.5-114.3 µg/L)  Secchi depth: 0.9 m (0.4-2.6 m)	Chla: 30 µg/L  Secchi depth: 0.6 m
Ozark Border	Largemouth bass, bluegill, white crappie, black crappie, redear sunfish, green sunfish, gizzard shad, common carp (invasive), channel catfish (stocked)	N/A	Chla: 13.6 µg/L (1.5-35.7 µg/L)  Secchi depth: 1.4 m (0.7-4.0 m)	Chla: 22 µg/L  Secchi depth: 0.7 m
Ozark Highlands	Largemouth bass, bluegill, white crappie, black crappie, redear sunfish, green sunfish, gizzard shad, common carp (invasive), channel catfish (stocked)	Largemouth bass, smallmouth bass, spotted bass, bluegill, walleye, longear sunfish, rock bass, white crappie, black crappie, walleye, gizzard shad, threadfin shad, common carp (invasive), channel catfish, flathead catfish, blue catfish, freshwater drum, white bass, bigmouth buffalo, smallmouth buffalo, river carpsucker, river redhorse, black redhorse, logperch, brook silversides, paddlefish, longnose gar, shortnose gar	Chla: 7.3 µg/L (1.1-25.3 µg/L)  Secchi depth: 2.0 m (0.8-4.3 m)	Chla: 15 µg/L  Secchi depth: 0.9 m

<sup>a</sup>Data from Jones et al. (2008).

<sup>b</sup>Justification for these criteria are listed below.

